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LBNL Research on Data Center Efficiency

The heady days of the dotcom boom may be over, but California's utilities continue to receive requests for proposed new data centers that anticipate needing large amounts of power. Without reliable information on whether the projected demands are accurate, these requests can be difficult for the utilities to assess. In response, LBNL's Applications Team has been studying California data centers to see what the real load patterns are and to look at the efficiency of individual systems.

Key areas of research underway at LBNL include benchmarking energy use in data centers, identifying best practices, and conducting research and activities directed at improving the efficiency of data center building systems and IT equipment.

Since 2002, LBNL's benchmarking effort has analyzed fourteen sites in California, with analysis underway on six more facilities. The researchers have found that "the average load is nowhere near the claims that were being made three or four years ago," according to Bill Tschudi, principal investigator. "We're finding on average 25 to 50 watts per square foot for the IT equipment loads, where claims were being made for 100 to 200 watts per square foot four to five years ago."

Although the high projected loads don't seem to have materialized, the bench

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The load intensity of data centers is growing rapidly. Photo courtesy of LBNL.

Lowering the Energy Use of Data Centers

This issue of e-News *focuses on some of the key strategies for designing energy-efficient data centers. For more detailed information, stay tuned for an upcoming Design Brief from Energy Design Resources on best practices for data center design.*

Each year brings advances in the performance of the information technology (IT) equipment housed in data centers. The buildings themselves, however, and the mechanical systems that serve them, haven't enjoyed similar leaps in performance. That could change if more design teams and owners embraced best practices for data center design.

Data Center Loads

A data center doesn't refer to a server or two wedged into a company's closet. Lawrence Berkeley National Laboratory defines a data center as "a special facility that performs one or more of the following functions: store, manage, process, and exchange digital data and information; provide application services or management for various data processing, such as Web hosting Internet, intranet, telecommunication, and information technology."

Data centers generally have specialized cooling and electrical power systems. The facilities operate 24 hours a day, 7 days a week, so they have very constant HVAC loads. Even though today's powerful servers are smaller than in the past, the load intensity in data centers is growing rapidly along with improvements in IT technology. A recent benchmarking study by

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Events and Conferences

June 23, 2005

Getting Started With Commissioning: for Owners and Managers
San Diego, CA

This seminar will give attendees the information and materials to take the first steps towards implementing commissioning or retrocommissioning in their facilities.

www.cacx.org

June 28–29, 2005

West Coast Energy Management Congress
San Diego, CA

The largest energy conference and technology expo held in California specifically for business, industrial and institutional users.

www.energyevent.com

July 19–22, 2005

2005 ACEEE Summer Study on Energy Efficiency in Industry
West Point, NY

"Cutting the High Cost of Energy," a three-day conference on increasing the energy efficiency of industry.

www.aceee.org/pubsmeetings/curmtgindex.htm

August 14–17, 2005

Energy 2005: The Solutions Network
Long Beach, CA

A major workshop and networking forum for federal energy managers and their private sector counterparts.

www.energy2005.ee.doe.gov

HVAC and electrical system designs are often based on incorrect assumptions about average loads.

Lawrence Berkeley National Laboratory (LBNL) found that IT equipment load (heat load) has almost doubled over the past three years (see sidebar on page 1). With real estate at a premium, facility owners naturally try to fit as much IT equipment as possible into their data centers, and all the heat produced by the equipment must be removed from the space.

Opportunities for Designing Energy-Efficient Data Centers

A number of key strategies contribute to the energy efficiency of data centers, including integrated design, right sizing, optimized air management, and efficient cooling.

Integrated Design

The integrated design of new commercial buildings often starts with architects exploring core-and-shell solutions to lower demand, such as optimizing building orientation and glazing. Data centers, however, are dominated by large internal electrical loads, and building shell effects are minimal. To employ an integrated design approach with a data center, it may be more effective to have the mechanical and electrical engineers lead the way. The focus would be more on what goes on *inside* the building than on the core and shell, and in particular how the building is cooled.

The integrated design of data centers also means selecting efficient IT equipment, since that can represent over half of a data center's energy use. Although IT equipment selection is outside the scope of the design team, responsible architects and engineers will help their clients understand the impacts that inefficient equipment will have on the building's upfront capital and long-term operating costs, and will encourage the owners to select more efficient products.

Building commissioning, a quality-assurance process that increases the likelihood that a newly constructed building will meet client expectations, is also an important aspect of integrated design. All too often data center owners spend a lot of money on backup systems and equipment to improve reliability, but are reluctant to invest in commissioning of the building and training of the facility operators. Yet these activities can significantly lower costs because they reduce the likelihood of problems with the building and its systems, and if a problem does arise, the owner has trained personnel who can fix it.

Savings By Design, a program sponsored by four of California's largest utilities under the auspices of the Public Utility Commission, provides tools and incentives for the integrated design and construction of energy-efficient commercial buildings, including data centers. To find out more, visit www.savingsbydesign.com.

Right Sizing

Too often, HVAC and electrical system designs are based on incorrect assumptions about average loads. At Lawrence Berkeley National Laboratory, where data centers have been benchmarked since 2002 (see sidebar on page 1), researchers have found that average data center IT equipment loads are 25 to 50 watts per square foot, compared to frequent claims of 100 to 200 watts per square foot.

"One quick opportunity," notes Bill Tschudi, LBNL's principal investigator on the study, "is to see if you can't size your HVAC and electrical systems effectively and/or provide a way to grow them efficiently in the future. The idea would be to design and build what you need now; if you're worried

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LBNL Research on Data Center Efficiency

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marking study is showing increases in load intensities from what was measured just two or three years ago compared to what is being measured today. "There does seem to be an increase in average heat intensity," says Tschudi. "We're trying to look at load intensities and efficiencies in some of the key systems, namely the HVAC systems and the uninterrupted power supply (UPS) systems."

The research project's components include training sessions, case studies, a Web site, and demonstration projects sponsored by PG&E and the California Energy Commission. For more information, visit http://hightech.lbl.gov/datacenters.html. ■

About *e-News*

Don't miss future issues—to sign up for a free email subscription, please visit www.energydesignresources.com/enews.php. Send letters to the editor, suggestions on topics for future issues, or other comments to admin@energydesignresources.com.

e-News is published by Energy Design Resources (www.energydesignresources.com), an online resource center for information on energy efficiency design practices in California.

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Energy Design Resources
Your Guide to Energy Efficient Design Practices

Savings By Design
Resources for Energy Efficient New Construction

about future growth, make it modular so that you can efficiently add to it in the future."

Optimized Air Path Management

Another major area for energy savings is to optimize the path that air takes around the cooling equipment; in other words, get the cooling where it needs to be. One solution is to provide hot aisles and cold aisles to separate heat rejection and cooling through either an underfloor or overhead air supply system. With this strategy, the servers are positioned in racks so that their fronts face a cold aisle and their backs face a hot aisle. Chilled air flows in front of and is drawn into the servers, while the hot air they produce exits at the back of the equipment and rises to return air grilles positioned in the ceiling above the hot aisle.

In data centers that aren't designed with a hot aisle/cold aisle strategy, the HVAC system has to circulate a tremendous amount of air in order to mix the air and prevent hot spots. This can lead to very high fan energy use. A hot aisle/cold aisle strategy is a relatively simple concept that can reduce cooling and improve reliability.

Another solution is to avoid the short circuiting of air flows. Hot air sometimes finds a path back to the front of the equipment, either by flowing around the top or sides of the rack or through any openings in the rack. Careful attention to the layout of air distribution and its return to the air conditioning units will help mitigate this problem.

Efficient Cooling

There are a number of opportunities for providing ample cooling while lowering energy use:

- *Improve chilled water system design.* Many well-understood best practices for chilled water system design aren't fully implemented in data centers. Opportunities to optimize chilled water systems include using variable-speed chillers and variable-speed pumping, and establishing an efficient chilled water temperature. Energy Design Resources' Design Brief, "Chiller Plant Efficiency," provides useful guidance (www.energydesignresources.com/resource/24).
- *Consider free cooling.* Although outside air and water-side economizers offer potential for significant energy savings, the use of outside air remains controversial. Some IT managers fear that the introduction of outside air might affect the reliability of IT equipment or lead to warranty issues. LBNL's research, however, indicates that some data centers use outside air economizers extensively and report no problems, reports Tschudi. For more information about energy-saving design using economizers, see Energy Design Resources' Design Brief, "Economizers" (www.energydesignresources.com/resource/28).
- *Reconsider air handler design.* Most data centers in California use commercially available computer room air conditioners (CRACs), some of which have self-contained heating and cooling coils. Unfortunately, CRACs are not as efficient as conventional large air handlers.
- *Consider broader temperature and humidity ranges.* In 2004, ASHRAE published *Thermal Guidelines for Data Processing Environments*. This document defines environmental conditions for various classes of IT equipment, including a broadening of the allowable temperature and humidity ranges. Taking advantage of these broader ranges in the design will lead to greater energy savings, according to Tschudi. ■

June Training Schedule

Partial list of classes. For a complete list, visit each energy center's Web site.

Date	Course	Time	Location	Units
Jun 14	*Exploring the New and Improved Functional Test Guide*	9AM–4:30PM	PEC	6
Jun 14	*IHACI: Preventing Compressor Failures/Refrigeration Cycles*	5:30PM–9PM	ERC	
Jun 14	*Integrated Demand-Side Management Training*	1PM–5PM	CTAC	
Jun 14	*Package Unit Heating, Ventilation & Air Conditioning*	8:30AM–12PM	CTAC	
Jun 14	*Advanced Lighting Technologies*	8:30AM–12:30PM	CTAC	4
Jun 15	*Collaborative for High Performance Schools (CHPS)*	8:30AM–4PM	San Diego	6
Jun 16	*Evaluating Combined Heat and Power (CHP) Applications*	9AM–4:30PM	PEC	6
Jun 16	*Retrocommissioning Workshop Two*	9AM–4:30PM	PEC	
Jun 17	*Splash into Summer Savings: Energy Efficient Hotels/Motels*	8:30AM–12:30PM	CTAC	
Jun 21	*SCE Cost Manager*	8AM–12PM	Westminster	
Jun 21	*SCE Bill Manager*	1PM–5PM	Westminster	
Jun 21	*Energy Management Systems (EMS)*	8:30AM–4:00PM	CTAC	
Jun 22	*Basics of Photovoltaic (PV) Systems for Commercial Applications*	9AM–4PM	Stockton	
Jun 23	*Comparing Motors and Engines as Prime Movers*	8:30AM–4:30PM	CTAC	
Jun 23	*Basic Heating, Ventilation & Air Conditioning (HVAC)*	8:30AM–12PM	CTAC	
Jun 28	*High Performance Schools: The CHPS Program*	9AM–4:30PM	ERC	6
Jun 28	*Integrated Demand-Side Management Training*	8AM–12PM	CTAC	
Jun 28	*Basic Lighting for Commercial & Industrial Facilities*	8:30AM–12PM	Murrieta/ Temecula	3.5
Jun 30	*Basic Lighting for Commercial & Industrial Facilities*	8:30AM–12PM	Hesperia	3.5

Training Locations

Location	Explanation	Phone	Website
CTAC	SCE's Customer Technology Application Center, Irwindale	(626) 812-7537	www.sce.com/ctac
ERC	Southern California Gas Company's Energy Resource Center, Downey	(562) 803-7500	www.socalgas.com/business/resource_center/erc_seminar_info.shtml
Hesperia		(626) 812-7537	www.sce.com/ctac
Palm Desert		(626) 812-7537	www.sce.com/ctac
PEC	PG&E's Pacific Energy Center, San Francisco	(415) 973-2277	www.pge.com/pec
Murrieta/Temecula		(626) 812-7537	www.sce.com/ctac
San Diego		(858) 636-5726	www.sdge.com/construction/ee_commercial_newconst_training.shtml
Stockton	PG&E's Energy Training Center	(800) 244-9912	www.pge.com/stockton
Westminster	Westminster Building	(626) 812-7537	www.sce.com/ctac